NASA-CR-203597

NASA-CR-203597 (annotations): NAG5-950; NDIB; IN-89-CR; 027657

Cool Stars, Stellar Systems, and the Sun, Eighth Cambridge Workshop
ASP Conference Series, Vol. 64, 1994
Jean-Pierre Caillault (ed.)

ZAMS STARS IN OUR OWN BACKYARD – THE ROTATION-ACTIVITY RELATION

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ABSTRACT

We present chromospheric (Mg II λ2800), transition region (C IV λ1550), and L_x (*ROSAT*) rotation-activity relations for a tiny, but homogeneous, sample of solar neighborhood K dwarf members of the Pleiades Moving Group. Stars with rotation periods $\lesssim 3^d$ show saturated TR emissions, but chromospheric emissions appear to be saturated at least out to $P_{rot} = 5^d.4$. Coronal surface fluxes clearly depend on rotation for $P_{rot} \gtrsim 3^d$; the situation for $P_{rot} \lesssim 3^d$ is unclear. We compare these results with recent studies of the Pleiades cluster.

INTRODUCTION

The nearest cluster ZAMS cool stars are the K dwarfs in the Pleiades ($d \sim$ 125 pc), which are too distant for coronal and transition region (TR) spectroscopy. Therefore, in order to determine the initial upper atmospheric properties of ZAMS cool stars, we have obtained *ROSAT* PSPC and *IUE* observations of a rare, homogeneous sample of solar neighborhood ZAMS K dwarfs. The 6 stars (Table I) are all single, between spectral classes K0 V and K2 V, have very high activity levels, and near-primordial Li abundances. The only variable is rotation: photometric (*i.e.*, true) rotation periods range from $8^h - 6.6^d$ (Table I). These stars are members of the Pleiades Moving Group on the basis of *U, V, W* space motions (Table I; compare with other moving groups in Soderblom & Mayor 1993). Most are within 20 pc.

DATA REDUCTION AND ANALYSIS

All usable *IUE* Archive spectra, including our own phase-resolved spectra for HD 82443, HD 82558, HD 220140, and a solar neighborhood Hyad, HD 37394 ($P \sim 11^d$), were reduced using standard *IUE* software for the LWP-Hi spectra, and a new, state-of-the-art automated reduction routine (Ayres 1993) for the

SWP-Lo images. Surface fluxes were calculated using the $(B-V)$ Barnes-Evans relation (Barnes, Evans, & Moffett 1978).

TABLE I. Properties of the Program Stars.

Star	Sp	V (mag)	d (pc)	P_{rot} (days)	log Li	Space Motions U	V	W
HD 197890	K0 V	9.3	~48	0.34	2.8	-06	-11	+01
HD 82558	K1 V	7.8	20.8	1.66	2.8	-26	-06	-15
HD 1405	K2 V	9.2	~38	1.75	3.0	-07	-34	-23
HD 220140	K2 V	7.5	~21	2.76	3.0-3.2	-11	-25	-04
HD 82443	K0 V	7.0	19.6	5.36	2.8	-14	-25	-02
HD 17925	K2 V	6.0	7.9	6.6	2.5	-15	-17	-11
				Pleiades Group		-09	-27	-12

X-ray fluxes for all but one of the stars in Table I were obtained from *ROSAT* PSPC (0.1 - 2.0 keV) sky survey observations, and were reduced using standard survey software. The PSPC flux for Speedy Mic (HD 197890) is a preliminary quiescent value from a pointed observation. Surface fluxes were obtained using the B-V Barnes-Evans relation, as above.

RESULTS AND DISCUSSION

The three rotation-activity relations are shown in Fig. I. In general, the results are consistent with the picture (*e.g.*, Simon, Herbig, & Boesgaard 1985) that higher temperature (TR and coronal) emissions decay faster with rotation (or age) than cooler emissions. Thus, TR (C IV) fluxes follow a clear rotation-activity relation for periods greater than $\sim 3^d$, while emissions are still saturated for shorter periods.

On the other hand, any decay in the chromospheric Mg II λ 2800 fluxes is marginal: these cooler emissions appear to be saturated at least out to HD 82443 at $P_{rot} = 5.4^d$, and possibly out to $P_{rot} = 11^d$. This differs from the recent chromospheric (Ca II H+K) rotation-activity relation for Pleiades cluster stars (Soderblom et al. 1993) in which only stars with $P_{rot} < 2^d$ are chromospherically saturated. One reason for this disagreement is that the Soderblom et al. study includes stars in different evolutionary stages, i.e., post-ZAMS F-G stars which are no longer saturated, while the stars in Table I are ZAMS stars in a very narrow temperature and evolutionary range.

Interestingly, the transition at $P \sim 3^d$ from saturation to rotation-governed activity levels, seen both for TR and coronal fluxes in Fig. I, agrees with the recent *ROSAT* study of the Pleiades cluster by Stauffer et al. (1994): their transition $v \sin i > 15$ km s^{-1} converts to $P_{rot} \sim 2.8^d$ (assuming $R = 0.85\ R_\odot$). However, the coronal flux for the very rapid rotator Speedy Mic (HD 197890) may indicate a gradual rise in coronal emissions for $P_{rot} \leq 3^d$ (Fig. I), rather than a saturation level completely independent of rotation. More proxy Pleiads

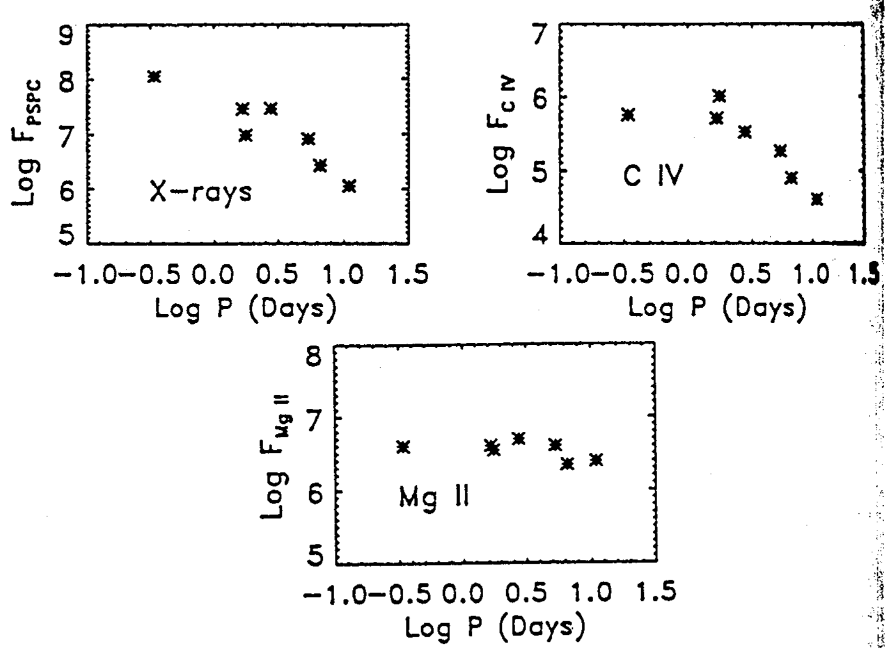

FIGURE I The coronal (*ROSAT* PSPC), TR (C IV), and chromospheric (Mg II) rotation-activity relations for the stars in Table I. Also included is a solar neighborhood Hyad, HD 37394 (P_{rot} = 11 d), for comparison. The X-ray surface flux for Speedy Mic (HD 197890) is tentative, pending further analysis. Except for HD 1405, which has only one C IV and one Mg II observation, the data points represent means of between 4 and 9 (quiescent) surface fluxes. Because the stars have essentially the same spectral type, there is no advantage in plotting Rossby number rather than P_{rot}.

with periods less than $\sim 1^d$ are needed to confirm this.

CWA is pleased to acknowledge support from NASA grant NAG 5-980. AB acknowledges support from NASA grant NAG 5-1792.

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